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Irrigation Works in the Hawaiian Islands

By M. M. O'Shaughnessy, M. Am. Soc. C. E., San Francisco.

(CONTINUED FROM PAGE 443)

KOHALA DITCH.

Surveys for the Kohala ditch were commenced in January, 1905, under the writer's direction. Construction work was begun the first week in April and water was flowing in 14 miles on the 11th of June, 1906. This ditch is located on the north slope of the Island of Hawaii, in the Kohala district, and conveys the water from a highly precipitous mountain country to the level cane fields in Kohala. The work was conducted under the greatest difficulties, as almost continuous rains were experienced from April to July, during all of which time trails had to be made and materials transported, and shelter and buildings made for housing 600 Japanese laborers. Those men seemed to like this class of work and made a success of breaking rock where other nationalities were a failure. As their wages average only $1 per day for the ordinary classes of lava rock encountered hand drilling with Japanese is more economic than the use of either air or electric drills. An experiment was made in one case with a highly advertised gasoline drill, which proved an absolute failure and had to be consigned to the scrap heap.

KOHALA COAST.

In the 14 miles there were:

45 tunnels, aggregating	46,000 feet.
20 flumes, aggregating	2,000 feet.
Ditching	23,000 feet.
Total	71,000 feet, or 14 miles.

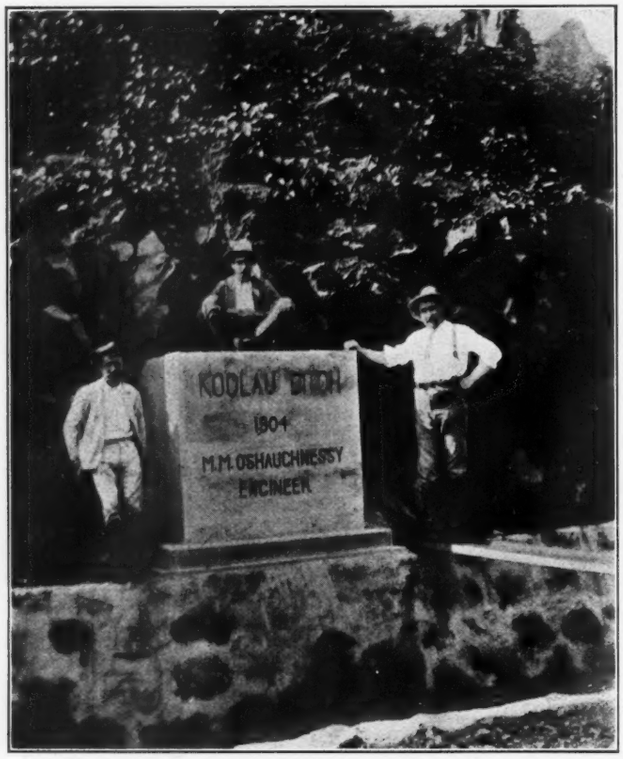
The longest tunnel was 2,500 feet, and was cut through in 10 months, being completed on the 24th of March, 1906.

TUNNELS.

The tunnels in this work were altered slightly in section from the ones in Olokele and Koolau as the sides were tapered, the bottom width being 6½ feet, 5 feet up the width was 8 feet and the crown of the arch was 7 feet above the floor. The object of this modification was to make a better bedding for the concrete lining than that afforded by vertical sides.

FLUMES.

The flumes were of the most substantial kind, thoroughly calked and tarred, being 7 feet wide by 5 feet deep. They were supported by three 10x12-inch posts on 10x12-inch sills, resting on masonry piers set in cement mortar 16-foot centers,



TABLET.

the top of the masonry being well above the flood line so as to lengthen the life of the timber.

DITCHES.

The ditches are 12 feet wide on the top, 7½ feet wide on the bottom and 4½ feet deep and lined with ¾-inch thickness of cement plaster (one of cement and two of sand), capped on each side by 6x6-inch concrete rims.

GRADES.

The fall in tunnels and flumes is one foot in 833 feet, and in ditch to Hawi is one foot in 1,000 feet. The elevation of the bottom of intake above sea level at first large stream (Honokane) is 1,035 feet, and at the terminus in the plantation fields 956 feet.

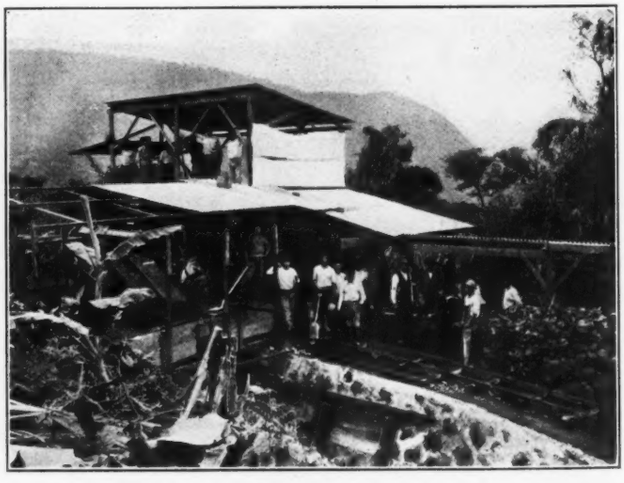
KOHALA DITCH, HAWAII.

MEASURING WEIRS.

There are two main measuring weirs, consisting of three panels each, with five-foot openings, capable of measuring up to 70,000,000 gallons daily, the capacity of the ditch when full.

CEMENT LINING.

In the 14-mile section about 10,000 barrels of cement, 2,500 cubic yards of crushed rock and 6,200 cubic yards of sand were used in lining the sides and bottoms of the tunnels where necessary to obviate seepage in porous strata and by arching to prevent caving in weak formations. The beach sand was rather poor in quality and the cost of packing, hauling and handling to the point where used on the ditch made it more expensive than crushing the materials on the site from blue rock with the rock crusher which was installed for this purpose. The sand, cement and rock were trammed through the tunnels in cars pulled by mules, which was found to be a very economical means of distribution. The hauling



ROCK CRUSHER.

and distribution of materials was done at night and the mixing and placing by the day shifts. Six inches of concrete or stone masonry was placed 5 feet high on the sides and an arched concrete roof, with weep holes, was placed where the ground was of a caving nature. The cement purchased was A-1 imported Alsen and Germania brands, averaging $2.60 per barrel in Honolulu. The steamer and other transportation rates from Honolulu averaged $1.30 per barrel more. The following gives the quantity of cement work done on this job:

Stone masonry and cement, 5 feet high sides	22,425 ft.
Concrete, 5 feet high	9,145 ft.
Cement plaster, ¾-inch thick on ditch	19,035 ft.
Arched concrete roofing	3,923 ft.
Bottom plaster to floor of tunnels	20,000 ft.
Masonry and flume piers	1,000 cubic yds

An hospital and medical department was also provided for the men, who were assessed 50 cents per month apiece for this object. The Japanese are indifferent to weather conditions, rain and exposure seeming to keep them in a healthy condition, while white men, similarly exposed, would be disabled by rheumatism and other ailments. While prone to listen to the advice of agitators, compared with similar bodies of white men working under similar conditions their conduct may be considered conservative.

HOUSING ARRANGEMENT.

All the men were housed under corrugated iron roofs, framed by light scantlings, such as 2x3 inches, which could be easily packed. The side walls were made of eight-ounce duck tacked to the scantlings and the floors were 1x12-inch, nearly always two feet above the ground and higher if practicable, so as to provide a place for drying the men's clothes in wet weather. Such accommodation was found much better and healthier than tents, which quickly rotted under the heavy rains.

TYPICAL MINERS' CAMP.

About 250 draught and pack mules were used on this work, the native Hawaiian mule being very handy and durable for packing purposes. The cost of this work was about $402,000. The price paid by the plantations for the water which is measured to them over weirs from the ditch is $2,500 per 365,000,000 gallons. About half the work was inaccessible to wagon roads, and narrow pack trails about five feet wide were cut out of the sides of the mountain precipices and used for packing materials.

The type of track used by me in all this work consisted of band rails 1½ inches wide and 3-16 of an inch thick, 16 feet long, with holes reamed out for track spikes about two-

foot centers. Those were spiked to longitudinal 2x3 sleepers nitched into and clamped with hardwood wedges to the ties about four-foot centers. Those ties were procured from the native woods of the country encountered along the rights of way. The track gauge in all cases was 18 inches. The rock cars used for conveying materials were 3 feet wide by 4½ feet long and were made on the ground and mounted on 12-inch wheels on 2-inch axles, the whole car being tipped off the track and one sideboard lifted when emptying. The miners liked those cars better and found them more efficient than the ordinary automatic iron ore cars, which cost three times as much. Below is a table showing the number of caps, fuses, powder and candles used per foot in the construction of the Koolau ditch:

CONSTRUCTION TRACK.

KOOLAU TUNNELS, 1903.

Consumption per foot.

Five pounds of powder at 15c.	$0.75
8.9 caps	.067
16.9 feet of fuse	.084
0.6 pound of candles	.072
Per two cubic yards of excavation	$0.973

It was generally found more advisable to do all work on a contract basis, paying so much per running foot, increasing the price on a fixed rate for each hundred feet that the tunnel extended in length, compelling the miners to pay for all the ammunition and candles used each month. In this way they were more economical in using the materials than if such were furnished them free. This experiment was tried in my first work at Olokele and found to be expensive, as the men wasted powder in a reckless manner, and it was impossible to curb the extravagance.*

Associated with me in this work for the past four years have been Mr. W. E. Sauer, C. E.; Mr. J. Jorgenson, C. E.; Mr. E. F. Rogers, a California miner; Mr. A. Glennan, Mr. P. Bluett and Mr. H. Cooper.

GROUND-WATER.

The most novel development in water supply has been the discovery of water by driving tunnels into the lava formation at high altitudes in encouraging localities. It is very difficult to predict what success will reward any outlay in this field, as the results are all problematical. A 2,000,000-gallon flow has been developed at an altitude of 1,400 feet at Waianae, on Oahu Island, by a 500-foot tunnel; while at Lahaina, on Maui, at an altitude of 2,600 feet, a 6,000,000-gallon daily flow has been developed by 2,600 feet of tunnel in a formation the exterior surface of which showed no signs of water, such as springs, etc., and this volume has kept practically constant for two years, fluctuating slightly with

* The average cost of excavating the tunnels, including supplies, track and labor, was $4.50 per foot.

(Statistics of Pumping Plants of the Hawaiian Islands.)

Compiled by M. M. O'Shaughnessy M. Am. Soc. C.E San Francisco.

Island	Agents for Plantation	Plantation	Manufacturer of Pumping Engines	Type of Water End	Dia. of Water Plungers.	Capacity in Gallons in 24 Hours	Total Lift in Feet	Water Horse Power	Diameter of Discharge Pipe	Length of Discharge Pipe	Type of Motor End	Size of Steam Cylinder H.P.	I.P.	L.P.	Stroke	Steam Pressure	Piston Speed per Minute	Coal Consumption in 24 Hours	Name of Coal Used.	Static Level of Water	Number of Wells.
Oahu	Alexander & Baldwin	Kahuku	H.R. Worthington	Four Cylinder Duplex Plunger & Ring	19¼" 21	5000000 6000000 12000000	210 150 50	187 154 105	24"	2560	Six Cylinder Triple Expansion	12	20	34	24	140	134	3½	Roslyn	10'-	4
"	" "	"	Fraser & Chalmers	Duplex Outside Packed	13 1/16"	8000000	347	486	24	3980	Four Cylinder Triple Expansion	15 5/8	26¾	28¾ 28¾	36	175	420	10	"	4'-	8
"	" "	"	Blake Co.	Duplex Plunger & Ring	36	14000000	55	135	30	800	Six Cylinder Triple Expansion	12	22	38	36	95	84	3	"	6	Open Sump
"	" "	"		Centrifugal	—	3000000 6000000	33 10	17 10	2-10"	225	Cummer High Pressure	16			24	70		2½	"	2	2
"	Castle & Cooke	Apokaa	Fraser & Chalmers	Single Packed Plunger	10	2500000	65	28	12"	2000	Single Corliss	8			24	100	284	21	Bituminous Co-Operative		1
"	" "	Ewa	" "	Duplex Packed Plunger	15⅞	11600000	51	114	30	200	Compound Corliss	12		18	36	140	420	5	" "		8
"	" "	"	Blake Co.	Duplex Plunger & Ring	12"	3000000	80	42	12"	300	Compound Slide & Poppet Valves	11		19	24	90	180	2	" "		2
"	" "	"	" "	" "	18"	7000000	105	129	30	1500	Compound Corliss	15		30	30	85	194	6.5	" "		8
"	" "	"	" "	" "	20"	9000000	105	166	30	3000	"	20		40	40	85	200	10	" "		8
"	" "	"	Fraser & Chalmers	Duplex Packed Plunger	16	10750000	105	197	30	1110	"	20		32	36	120	420	8	" "		6
"	" "	"	" "	" "	10 5/8	10123000	200	364	30	4730	"	24		40	42	120	800	11.5	" "		6
"	" "	"	" "	Triple Packed Plunger	11 5/8	11740000	160	328	30	1500	Triple Expansion Corliss	14¾	24	36	42	180	504	10	" "		6
"	H. Hackfeld & Co	Oahu	" "	Duplex Packed Plunger	11	5650000	450	445	30	1500						160	434	11.5			3
"	" "	"	" "	Triple Packed Plunger	11⅞	10700000	370	695	30	5000	Triple Expansion Corliss	19	33	50	42	175	460	14.1			7
"	" "	"	" "	Duplex Packed Plunger	12	6600000	550	638	24	9225						165	420	19			7
"	" "	"	" "	Triple Packed Plunger	11 7/8	10700000	344	645	30"	6000	Triple Expansion Corliss	19	33	50	42	180	460	15			8
"	" "	"	" "	Duplex Packed Plunger	15½	10300000	556	1000	24"	10000	Four Cylinder Triple Corliss	27	46	50 50	42	165	385	24			10
"	" "	"	" "	" "	14	8660000	146	222	24	2500	Compound Corliss	20		32	36	125	390	65			5
Maui	" "	Pioneer	Braunschweiger	Duplex Packed Plunger	11	5000000	465	408	14		Cross Compound Poppet Valves	23		38	42	180	370	10	Bituminous	Sea	6
"	" "	"	" "	" "	11	5000000	465	408	14		" "	23		38	42	180	370	10	"	"	6
"	" "	"	Worthington	Duplex Plunger & Ring	15	3000000	115	60	14		Six Cylinder Triple Direct Acting	8	12	20	15	125	120	4	"	"	2
"	" "	"	"	" "	15	3000000	115	60	14		"	8	12	20	15	125	120	4	"	"	2
"	" "	"	"	Duplex Packed Plunger	19	5000000	540	474	18		"	21	33	60	36	160	125	10	"	"	5
"	" "	"	"	Duplex Plunger & Ring	20	5750000	275	277	18		"	16	25	46	24	160	130	8	"	"	5
"	" "	"	"	" "	24	8750000	100	252	24		"	12	20	34	24	160	134	6.5	"	"	8
"	" "	"	"	Duplex Plunger & Ring	15½	3500000	460	281	16		Six Cylinder Triple Direct Acting	16	25	40	24	160	130	.7	"	Sea level	4
"	" "	"	"	" "	15	3000000	65	34	12												

"	" "	"	"	Duplex	24	8750000	100	252	24		"	12	20	34	24	160	134	6.5	"	"	8
"	" "	"	"	Duplex Plunger + Ring	15½	3500000	460	281	16		Six Cylinder Triple Direct Acting	16	25	46	24	160	130	7	"	Sea level	4
"	" "	"	"	"	15	3000000	65	34	12		"	6	9	16	15	160	120	3.5	"	"	3
"	" "	"	"		18	4500000	420	330	17			18	30	50	24	160	125	8	"	"	4
	Alexander + Baldwin	Haiku	Fraser + Chalmers	Duplex Packed Plunger	10⅝	5500000	440	425	20	4500	Compound Corliss	24		40	36	125	454	12	New Castle + Departure Bay	Sea	6
"	" "	"	"	" "	10⅜	4000000	256	180	18	550	"	18		30	36	125	350	5½	" "	"	4
"	" "	Kihei	H.R. Worthington	Duplex Plunger + Ring	20	600000	320	336	20	11500	Six Cylinder Triple Direct Acting	17	27	48	24	180	134	18			Open Sump -
"	" "	"	"	" "	20	600000	200	210	20	7350	" "	16	25	46	24	180	134				"
"	" "	"	Risdon	Duplex Packed Plunger	14⅞	7000000	450	551	28	4480	Four Cylinder Cross Compound Corliss	24	40	43 43	43	160	298	35			"
"	" "	"	Fraser + Chalmers	" "	14 9/16	10000000	350	612	28	1700	"	19	36	36 36	36	160	420				"
"	" "	H.C + S.Co.	—	Duplex Plunger + Ring	14½	7400000	110	143	24	5975	Cross Compound Popper Valve	16		32	36	80	312	6.2	Nanaimo British Columbia	Sea level	"
"	" "	" " " "	—	Centrifugal 40" Runner		2250000	65	26	18	2100	Single Cylinder High Pressure	16			36	80		4.8	" "	"	"
"	" "	" " " "		Duplex Plunger + Ring	14½	7750 000	95	130	24	1850	Cross Compound Side Valve	16		32	36	85	324	5.8	" "	"	"
"	" "	" " " "	Fraser + Chalmers	Duplex Packed Plunger	14⅛	8300000	209	305	28	4200	Cross Compound Corliss	24		32	42	125	372	8.6	" "	"	"
"	" "	" " " "	" "	Triple Packed Plunger	11⅞	8800000	184	283	30	7200	Triple Expansion Corliss	19	33	50	42	180	375	6.7	" "	"	"
"	" "	" " " "	" "	" "		8800000	314	483	30	10450	"	19	33	50	42	180	375	7.5	" "	"	"
"	" "	Paia	H.R. Worthington	Centrifugal		1500000	35	10	10		High Pressure Engine					90	294	3	Ladysmith	"	"
"	" "	"	Fraser + Chalmers	Duplex Packed Plunger			40		8	1200	Compound Corliss	9		18		90	180		"	"	"
"	" "	"	"	" "		4500000	425	334	18	5280	"	18		30		135	300	14½	"	"	"
"	" "	"	"	" "		5500000	450	433	24	10560	"	24		40		135	434		"	"	"
KAUAI	" "	Makaweli	"	Duplex Packed Plunger	13"	5000000	60	52	20		Cross Compound Corliss	10		20		150	260	2.9	Wellington		Main Ditch
"	H. Hackfeld + Co.	Koloa	"	" "	13⅞	6500000			24		"	12		20	24	120	300	3	New Castle Departure Bay	20	
"	" "	Kekaha	Risdon	Duplex Packed Plunger	15	8000000	54	75	30	1700	"	12		24	36	120	288	26	" "	20	7
"	" "	"	"	Four Cylinder Duplex Tandem Pkd. Pl.	15½ 10	10000000	19 56	98	24	2400	"	12		24	36	120	252	3.75	" "		12
"	" "	Hanamaulu		Duplex Plunger + Ring	10	3000000	84	41	16	750	Compound Hamilton Corliss	12		18		120	300	2.25			Open Ditch
"	T. H. Davies + Co.	McBryde	Fraser + Chalmers	Triple Packed Plunger	11	10000000	380	665	30	4450	Triple Corliss	19	33	50		160	490	18	Screened Seaham	10	18
"	"	"	Risdon	" "	14⅜	10000000	380	665	30	1200	"	25	43	66	42	165	290	18	"	12	18
"	"	"	H.R. Worthington	Four Cyl. Ver. Beam Engine	22	6000000	250	262	24	1000	Four Cylinder Triple Direct Acting	15 15	33	57½	36	150	112	14	"	10	10
"	Castle + Cooke	Waimea	Davidson	Duplex Single Acting	10	1000000	30	52	8	400	Compound Direct Acting	8		18	12	100	180	1	New Castle		5
HAWAII	" "	Kohala	Fraser + Chalmers	Duplex Packed Plunger	13 1/16	7600000	310	412	24	6000	Four Cylinder Triple	15⅝	26¾	28⅜ 28⅜	36	175	400	7	" "	5	Open Tuppels
	F. A. Schaefer & Co.	Honokaa	H.R. Worthington	" "	5½	400000	425	294	6	3000	Six Cylinder Triple Direct Acting	6	9	16	15	115	115	Trash is used		6	1

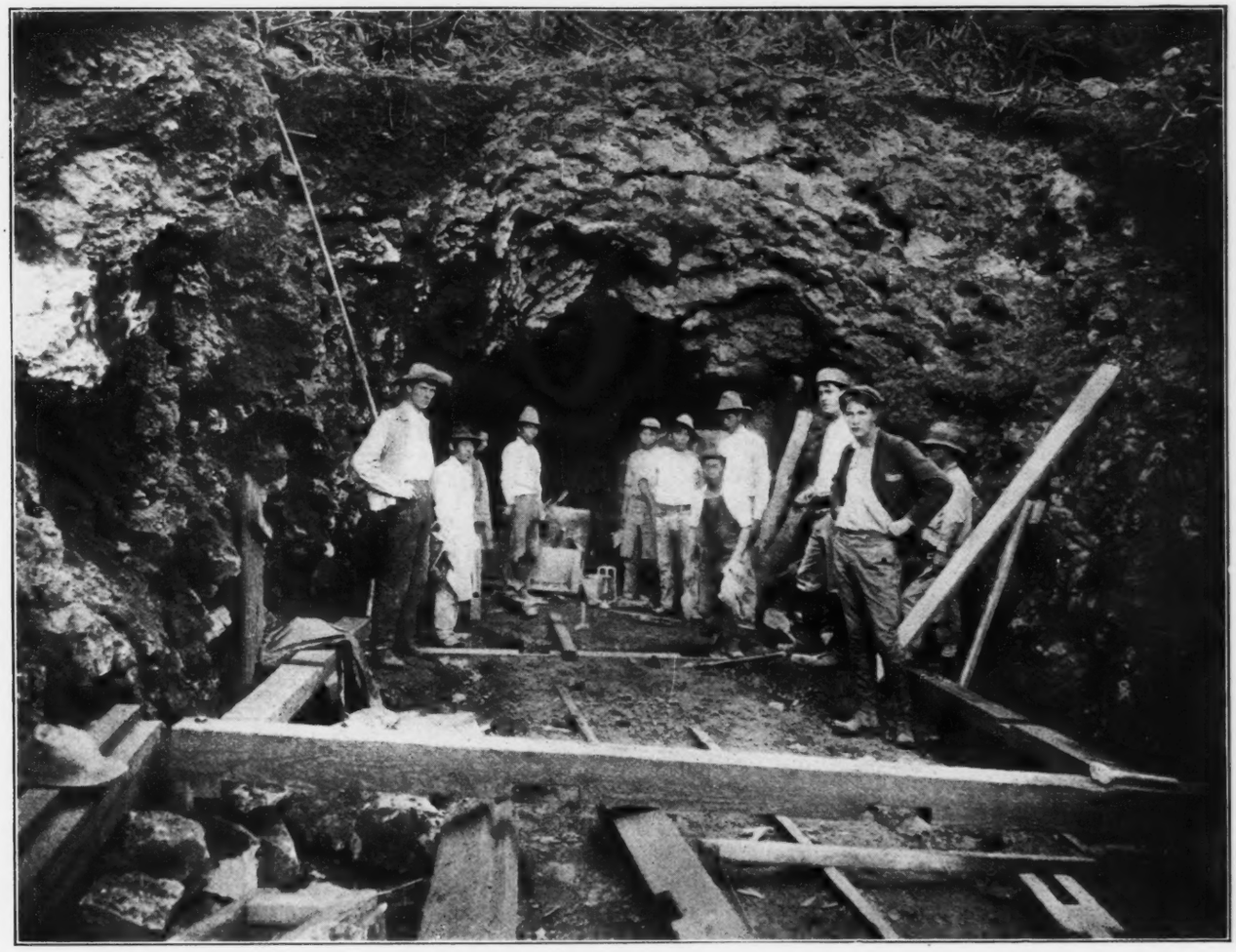
the rainfall on West Maui Mountains, in its immediate vicinity, 3,000 feet higher. On the other hand, in the 30 miles of aqueduct tunnels, cut under the writer's supervision in the past four years as conduits, no ground-water in any quantity has been intercepted except an occasional drip from tunnel roofs through porous stone.

DUTY OF WATER.

The quantity found necessary to irrigate each 100 acres is 1,000,000 gallons of water per day. Sugar cane is grown in furrows, about five feet apart, into which the water is turned from the field ditches. When the seed is newly planted the water is turned on every three or four days, but after that an application of once each 10 days is considered sufficient. The above quantity, if applied uniformly to the whole surface, would make a depth of 134 inches in one year, excluding rainfall and evaporation, which is possibly 50 inches yearly in most of the irrigated properties. It means the application, for a crop period of one year and a half, of 22,800 tons of water per acre to produce 50 to 80 tons of cane, which would appear to be excessive.

It is safe to presume that leaky reservoirs, ditches and unequal and wasteful distribution prevent the application of more than one-third of this quantity of water to the roots of the cane, where its value would be utilized.

Economies of various kinds in the application of water are now being gradually introduced, which will enable the best results to be obtained. Nearly all the water thus far developed has been used by the owners on their own property. Lately, surplus waters have been disposed of to adjacent owners, at a flat rate of from $8 to $10 per 1,000,000 gallons. Great credit must be given the American pioneers who have developed such splendid supplies under so many adverse conditions in the past twenty years in those remote islands of the Pacific. By no other people, except perhaps the Mormon settlers of Utah, has so much enterprise been displayed, and so many sacrifices made in developing a non-productive country into one of pronounced prosperity.



MASONRY TUNNEL LINING.

FOR GAS ENGINES.

Magnetos fitted with condensers and giving a high tension spark are fairly well known, and have been used with considerable success on motor car engines, but the accumulator and coil are still necessary for starting, as magnetos can only be brought into action when they are revolving at a good speed.

IRRIGATION OF SUGAR CANE IN THE HAWAIIAN ISLANDS.

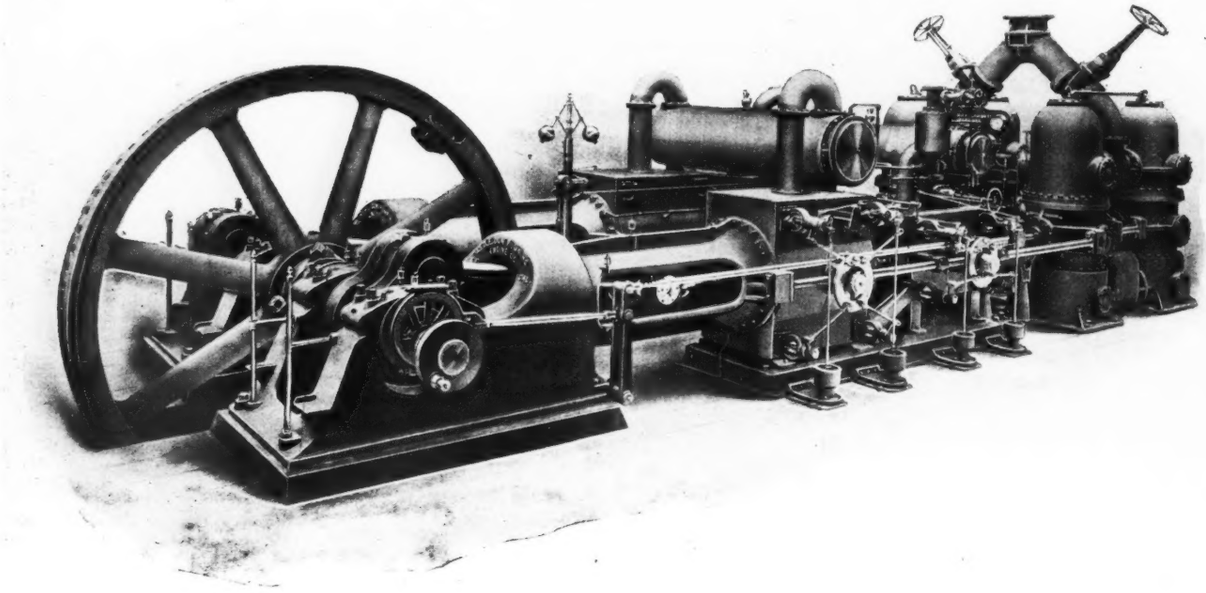
Irrigation may be regarded as a modern science and belongs to that branch of hydraulics which pertains to obtaining a requisite amount of water and delivering it to the land to be cultivated for the purpose of increasing the growth of vegetable matter. The quantity of water necessary depends largely upon the character of the soil and the product to be raised. There are but few instances where more water is required than in the cultivation of sugar cane. In the Hawaiian Islands the method of irrigation may be divided into two classes, the first being a natural water supply, and the second an artificial supply. In the foremr case, the source of supply is such that its elevation permits of the water being carried by the ditching to the cane land, but in many instances it is essential that large dams and reservoirs and many miles of ditches be constructed at a large first cost, but their operating expenses is comparatively small. When this plan is not feasible, it becomes necessary to obtain water from the lowest levels and pump it to a height into the main ditch from which it is led by smaller ditches to different points for distribution. In many instances, plantations having a natural supply of water do not entirely rely on this, but install pumping machinery so that either method may be resorted to. This is done in order to prevent great losses in case of accident.

Many irrigating propositions have failed for the reason that the mechanical methods used for raising water create a heavy running expense which could not be met by the plantation owners. It then became necessary to install new machinery, greatly increasing the first cost but materially reducing the former operating expense. As new plantation companies were organized, the first consideration, from a commercial point of view, was the subject of irrigation. Upon this depended the selection of lands, the method of cultivation and the construction of sugar mills, railroads, etc.

When one stops to consider the enormous production of sugar cane in these islands, and after understanding the peculiarities of the cane, the subject of irrigation naturally presents itself as one of the chief features of the industry. From the time the cane is planted until it is cut some eighteen or twenty months intereven, during which time the ground must be irrigated at the rate of about 10,000 gallons of water a day for each acre. Many of the plantations have under cultivation between seven and eight thousand acres, which require more than three times as much water as is used by the city of San Francisco. Continually raising such enormous quantities of water to the cane land must be accomplished by the most economical method known to engineering, as upon it depends either financial success or failure for the plantation.

The most modern and up to date pumping plant yet erected was installed in 1904 for the Honolulu Plantation Company, of which John A. Buck, of San Francisco, is president. This company recently added 1,400 acres of new cane land to its possessions, and this new land requires for its cultivation 14,000,000 gallons of water every day.

The gigantic pumping engines which supply this immense volume of water were designed and constructed by the Geo. E. Dow Pumping Engine Company, of San Francisco, and are the largest ever built on the Pacific Coast. On page 201 is illustrated one of these engines, the photograph of which was taken in the shops of the Dow Company just prior to the shipment of the engine to Honolulu. Each pump has a daily capacity of 7,000,000 gallons raised to an elevation of 450 feet. The water is taken from twenty-seven artesian wells, ranging from 600 to 1,200 feet in depth, which discharge their water into one common suction header forty-eight inches in diameter by fifty feet long, and sixteen feet above sea level. The pumps take their supply from this header and deliver it into a thirty-six-inch steel pipe which runs up the mountain side to the cane line and into a weir having a float and time recording instrument, so that at all times the exact flow of water is recorded.



As has already been mentioned, economy is the chief feature in such a huge undertaking. The type of pumping engine adopted by the builders in fulfilling their efficiency guarantee was a horizontal four-cylinder triple expansion crank and fly wheel with Corliss valve gear, using steam at a pressure of 180 pounds per square inch. The principal dimensions of each engine are as follows:

Diameter high pressure cylinder (1), twenty-two inches; diameter intermediate pressure cylinder (1), thirty-eight inches; diameter low pressure cylinders (2), forty-four inches; diameter water plungers (2), fourteen and three-fourth inches; length of stroke, forty-eight inches; total length, sixty-six feet six inches; total width, twenty-three feet eight inches.

Many new features have been introduced into this design, chief of which is the method employed for tying the steam and water ends together, i. e. by long steel tie-bars running from the crosshead yokes on the steam end along the sides of the cylinders directly to the plunger chambers on the water end. This construction has the advantage of a direct re-

sistance to the thrust of the piston rods. Another important change from former methods is the application made use of for driving the air, circulating and feed pumps. These three auxiliary pumps are designed as a single self-contained machine. They are located below the floor line and are constructed with a walking-beam and connecting rod leading to a crank disc which is keyed to the end of the main crank so that one revolution of the main engine produces a complete revolution of the three auxiliary pumps. The surface condensers, each having a total cooling surface of 1,400 square feet, are also located below the floor line. The pump rods and steam piston rods are connected by clamped crossheads of forged steel with adjustable shoes sliding on guides to take the weight of the reciprocating parts.

The water end embodies all the latest features of the well known Dow water works pump. It is of the outside central packed pattern with double acting plungers working through long bronze ilnings. Directly under the suction valves are large vacuum chambers so essential to the smooth action and perfect operation of the valves. The design of the valve decks is such that they can be removed without disturbing the alignment of the pump—a feature which has been found lacking in the older type of pump. The valve seats are screwed into the decks on a fine taper thread with machine power so that all danger of seats backing out is eliminated. The valve is designed particularly for this class of work, it being leather-faced and has a double discharge, constituting a construction that permits of an extremely low lift, which in many cases more than double the life of the valve. Relief valves are fitted both above and below the valves on the delivery line in order to protect the pump and pipe line against careless manipulation and mishaps.

Steam is furnished to both pumping engines by four 250-horsepower water tube boilers, located on the surface, while the pumps are enclosed in a concrete pit seventy-five feet long by fifty-five feet wide and six feet thick some thirty-two feet below the surface. The fuel used is California crude oil.

The entire plant, including boilers, pumps, piping and all auxiliaries, were furnished by the Geo. E. Dow Pumping Engine Company. The official duty tests were made under the supervision of Edwin T. Dow, representing the builders, and W. J. Dyer, representing the Plantation Company, and the result of the tests were alike pleasing to the Honolulu Plantation Company, and gratifying to the builders. Messrs. John A. Buck and James A. Low, president and manager respectively of the Plantation Company, were present during the trials. The duty obtained, being figured on a basis of weir measurements and with no corrections for moisture in the steam or any deductions whatever was 157,995,557 foot-pounds for every 1,000 pounds of steam supplied by the boilers, this being 17 per cent in excess of the guaranteed efficiency. The percentage of total efficiency was 94.2.

The following data was taken from the first engine during the trial:

Steam pressure, in pounds per square inch, 180; first receiver pressure, in pounds per square inch, 37.5; second receiver pressure, in pounds per square inch, 2; vacuum, inches, 27; water pressure, pounds per square inch, 195; revolutions per minute, 38.2.

PUMP LOCATIONS IN POWER PLANTS.

The location of pumping machinery in a power plant depends so largely upon the available space that in many cases the designer has little choice in the matter. Railway plants, as noted in the Street Railway Journal, usually offer a wider latitude in this respect than installations designed for office building or hotel service. In some of the higher class isolated plants a separate room is now provided for pumps, and there is no doubt that in certain railway generating stations such a course would be advantageous.

In some cases the pumping equipment is installed in the engine room, and the principal advantage of so doing is the increased amount of attention the pumps receive from the engineering staff of the station. In general the boiler room is not an ideal place for moving machinery, and although steam-driven feed and circulating pumps are rugged pieces of apparatus, there is no question that constant exposure to coal dust and dirt increases the rate of depreciation. Pumps and piping need care as well as anything else, and it is too much to expect the same attention in the boiler department as in the engine room.

The location of pumps in the engine room is open to the serious objection that such a course tends to crowd the equipment too closely together in plants where there is quite a number of pumps to be installed. Aside from boiler feed pumps, many plants are equipped with air and circulating pumps for condenser service, step bearing turbine pumps, oil pumps, drainage, artesian well and fire pumps. The piping complications which these entail are a disadvantage to the free movement of objects in the engine room, and to the clear vision of the operating force. The most modern stations are conspicuous for the way in which similar equipment is co-ordinated in groups of operating units; ample clearance is allowed between units, and the grouping plan permits the widest flexibility in case of trouble. Thus, if all the boiler feed pumps are installed in a parallel row in a separate pump room, the piping can readily be arranged to enable any pump to take up the load with minimum loss of time in case of trouble. If the pumps are scattered promiscuously around in odd corners the pipe layout can not be as simple and hence as low as in first cost, or the control as immediate and concentrated. Air and circulating pumps are almost always installed in the basement close by the condensers which they serve, but there is often the same opportunity for co-ordinating these in a group, with the feed and oil pumps, step bearing pumps, etc., that there is where the pumps are located in a separate compartment on the floor above. The pump installation ought to be well under the hands and eyes of the operating shift, in any case, and the plan of segregating this equipment in a group apart from the boiler and engine room apparatus is well worth bearing in mind in designing new plants. There is no reason why traditional practice in the location of pumps in the boiler room should not be departed from in cases where it seems advisable.

SUPREME COURT DECISION.

The Appellate Division of the Supreme Court, New York, has decided that the city of New York cannot inspect the books of the Brooklyn Union Gas Company in an effort to determine whether the company overcharged the city for gas supplied in the old Brooklyn district on public account during the period between January 7, 1903, and March 16, 1904. After the old contract with the city expired on January 7, 1903, the city rejected the bids of the gas company as too high. Until a new contract was signed bills were presented to the city for the gas used at a rate of 90 cents per 1,000 cubic feet, an aggregate of $135,133.14. Bills for labor and material, amounting to an additional $126,988, were also presented. These bills the city decided were exorbitant and Corporation Counsel Delany gave it as his opinion that the company was compelled to furnish light to the city and depend for collection on what should be determined by the courts to be a reasonable price. The opinion of the Appellate Division, written by Justice Gaynor, points out that as the price was fixed by the legislature at $1.25 per 1,000 feet, the courts have no power to lower it. Justice Gaynor says the courts cannot be permitted to set aside acts of the legislature which do not violate the constitution.—American Gas Light Journal.

APPLICATION OF THE PRINCIPAL TYPES OF POLYPHASE INDUCTION MOTORS.*

W. Edgar Reed.

In order to choose the proper motor for a given service, it is necessary to know the requirements and the characteristics of motors which may be used for this work. When these are known the motor that is best suited for a given class of work can be determined.

The principal types of polyphase induction motors may, for convenience in applying them, be classified according to their operating characteristics as constant and variable speed motors. The most important characteristics to be considered in making applications are the speed-torque curve (or automatic variation of speed for different torques or horsepower outputs of the motor), the maximum starting torque and corresponding current, the rating or load the motor will carry for a given time with satisfactory temperature rise, and the efficiency and power-factor under these different conditions.

The variable speed motor has very large slip, and hence a large variation in speed for changes in torque, or in other words, the poorest speed regulation and low efficiency, other conditions remaining the same. It develops the maximum torque at starting with minimum starting current. The value of maximum and starting torque will be at the intersection of the speed-torque curve with the axis of torque or at zero speed. Motors of this type are sometimes designed to have a speed-torque curve that approaches a straight line. These motors have been frequently called the "straight line motors." The average motor of this type is designed to develop a starting torque of not less than two and one-half times full-load torque, and the starting current taken by the motor will be approximately four times full-load amperes (or one and one-half times full-load amperes for full-load torque if reduced voltage is applied).

The slip, starting torque and starting current of induction motors may be varied by changing the rotor resistance. An increase in resistance within limits increases the slip and starting torque, and diminishes the starting current. The maximum torque is practically unchanged by variations in rotor resistance.

Ratings.

Constant speed motors are generally rated so that they will carry normal load continuously with a rise in the temperature of forty degrees C., or less, twenty-five per cent overload continuously, with a rise of sixty degrees, or less, and fifty per cent over-load for one hour with a rise of fifty degrees, or less, all the temperatures being measured by the thermometer method.

Variable sped motors are generally operated under continually changing loads, and the best way to determine the size of motor required for a service is to determine the average losses for a given length of time or cycle of operations. A size of motor can then be chosen that will operate with these average losses. For this reason variable speed motors for industrial work are rated like series railway motors, that is, at a maximum horsepower for a one-half or one hour run with a temperature rise of forty, sixty or any other degree C. rise by thermometer. Curves can also be made which show the lengths of time a motor will carry different loads with a given temperature rise. These motors are given a number instead of a horse power rating as is done with railway motors.

Efficiency.

Constant speed motors with a minimum slip have the highest efficiency. With increased slip and secondary resistance the efficiency diminishes on account of the increased secondary losses. The efficiency of variable speed motors is lower, other conditions remaining the same, on account of their large slip and secondary losses.

*Based on a lecture delivered before the Electric Club of Pittsburg.

Power-Factors.

The power-factor at light load is very low, but increases rapidly with the load, and is generally very good for the constant speed motor at full load. The power-factor when starting with load may reach forty to sixty per cent. The power-factor curve of the variable speed motor follows the general form of that for the constant speed motor but is generally somewhat lower, especially for light loads. When severe starting conditions, requiring several times full-load current at a low power-factor, exist, their effect upon the supply circuit should be considered in making applications.

Types of Rotor Windings.

Polyphase motors are generally of the squirrel cage (short-circuited rotor) or the slip ring (wound rotor) type. The squirrel cage motor is the simplest mechanically. There is nothing to get out of order and its operation is entirely automatic. There are only a few volts generated in the secondary winding, and no trouble is experienced with insulation breakdowns. The motor, therefore, requires very little attention and expense for maintenance.

The starting current of a squirrel cage motor may be decreased by applying a lower voltage than normal, the torque, however, is proportional to the square of the voltage applied, so that the application of this method is rather limited unless the torque of the motor under normal voltage is very high. The lowest suitable voltage for the required starting torque should be used, however, as the shocks and strains upon apparatus connected to the motor are in this way also reduced.

The wound rotor is more complicated and difficult to make on account of the winding and insulation for higher voltages, sliding contacts and variable rotor resistances which must be inserted manually or automatically.

By using a variable rotor resistance in connection with a slip ring motor there are obtained some of the advantages of the high resistance rotor at starting and the low resistance rotor when running. A starting torque equivalent to full-load running torque can be obtained with a current only a little greater than full-load current, and the power-factor still be the same as under running conditions. This is a most important feature, especially when the starting current may effect the supply circuit. The efficiency will also be high under running conditions.

Different rotor resistances can be used for obtaining variable adjustable speed motors. The efficiency is lowered, however, as the speed is reduced, and this should be considered in making applications. For example, half-speed would mean fifty per cent loss in the rotor resistance and the efficiency of the motor would be less than fifty per cent. Also, under these conditions the speed is constant only for a given torque or horsepower, and will change as soon as the torque required changes. The speed will follow speed curves for different torques and there will be greater variation in speed for the high than the low resistance rotor.

Applications

The variable speed motor should be used when frequent severe starts are necessary and the period of operation is short, and where variations in torque and speed are great—for example, on cranes, elevators, hoists, railways, roller beds, bending rolls, reciprocating machine tools, punches, shears, etc. For elevator, or similar work where quick, frequent starts and stops are necessary, motors having a minimum inertia of rotating parts should be used. In this case it is advisable to use motors of the slowest speed and lightest weight of rotor that will give satisfactory operation. Although the efficiency of this motor at full-load is less than the constant

speed motor, yet as the motor runs only a short time at full-load, this is not of as great importance as the efficiency when starting, which is higher than for the constant speed motor. Variable speed motors are also used for starting rotary converters, synchronous motors, etc., where they must develop exceedingly heavy torques for a very short time.

Constant speed motors are generally used for that class of service which requires fairly constant power for a long period, good speed regulation, infrequent starting and only average starting torque, such as driving line shafting, high and low speed centrifugal and reciprocating, pumps, air compressors, blowers, fans, rotary motion machine tools, wood working machinery, lathes, boring mills, circular and band saws, motor-generator sets, frequency changers, continuous running constant loaded machinery, etc.

In general, the short-circuited type of rotor should be used when the motor is small compared with the size of the generating station; when the voltage regulation of the system would not be effected by the starting current required by large motors; when the starting conditions are not frequent or severe; when the motor is not accessible for frequent inspection and where simplicity is of great importance.

The wound rotor should be used when the motor is large compared with the capacity of the generating station; when good voltage regulation is necessary; when frequent starting is required and where large starting current would seriously affect, or be undesirable to, the system; for work at reduced speeds or where fairly heavy loads must be brought up to speed gradually.

PERFORMANCE OF APPARATUS UNDER ABNORMAL CONDITIONS.*

The term "standard" is applied to apparatus which is usually made in quantity and conforms to certain common or normal conditions with respect to voltage. frequency, speed and the like. Standard apparatus has a certain definite performance for which it is designed to operate under normal conditions. Individual pieces of apparatus may vary slightly one way or the other from the average or normal performance.

It happens quite frequently in the selection of apparatus that the conditions to be met differ from the average or ordinary conditions, so that if standard apparatus is selected it will be used under conditions differing from those for which it was designed. Motors, for example, are called upon to operate at different speeds, or at different outputs, or at different voltages from those for which they were intended. The question then presented to the commercial engineer is to determine whether standard apparatus is suitable; first, whether it will perform the required service, and second, whether it will do this safely and satisfactorily. Often the ingenious and resourceful engineer will be able to suggest some modifications in the conditions which will bring them within the range which standard apparatus is qualified to meet.

Hence, the importance of knowing what a given motor or other piece of apparatus will do under abnormal conditions. This, to be definite, may require specific knowledge with regard to the particular motor, for the reason that the range of variation permissible with a motor of one size or for a certain voltage is usually different from those of motors of other sizes or for other voltages. On the other hand, there are certain general relations between the different characteristics of apparatus, the understanding of which is usually helpful. For instance, if one knows the effect of a decrease in the speed of a generator upon its field current he will be able to form a fair idea of the difficulties which may be encountered if a particular machine is to maintain its normal voltage at a speed which is considerably below normal. If one knows the effect of a change in voltage upon the field current, upon the commutation and upon the heating of various elements he can predict the probable effect which may be expected from a change in the voltage of a particular machine.

It is profitable to study the effect which a change in one element makes upon others. The effects of over-voltage, under-voltage, lower frequency, higher frequency and a simultaneous change both in frequency and in voltage upon a particular induction motor are considered. This method of treatment and the general principles underlying the changes produced by varying certain elements give the article far more importance than do the particular figures with regard to a specific motor.

Further generalization is useful. With respect to over-voltage, for example, an increase of voltage is, in general, equivalent to increasing the capacity of the motor. An increase of 10 per cent. in the voltage increases the starting torque, the maximum torque and the output at a given slip by approximately 20 per cent. In other words, the capacity of a motor varies as the square of the voltage. A ten horsepower motor at 200 volts becomes a 12-horse power motor at 220, in sofar as its capacity is concerned. Its losses, however, are considerably greater, so that its temperature would be increased. Its efficiency and power factor will be lower. The suitability of the motor for continuous operation at a higher voltage and increased output depends, therefore, not upon its capacity to carry the load, but upon other features which have to do with safety and economy.

If the motor be run at the higher voltage, but with its normal output (in this case 10 horse power), then the motor has capacity for 12 horse power and is carrying only 80 per cent load. Several characteristics of a motor, such as slip, maximum torque and starting torque would approximate the ordinary figures for a motor of this size running at 80 per cent of its normal load.

Conversely, if a motor be run at 10 per cent below normal voltage, then the capacity is decreased about 20 per cent. A 10-hosepower motor would have the characteristics of an 8-horse power motor in starting and in maximum torque and in output at normal slip. If, at the lower voltage, the motor be given its full load of 10-horse power, its characteristics will be quite similar to those of a motor which is carrying 25 per cent overload.

The habit of thus establishing in one's mind the various fundamental relations between the different elements in the operation of a motor or other apparatus, by which one can forsee the effect which a change in once element will produce upon other elements, will prove very useful to most engineers who have to do with either the selection or the operation of apparatus. It is further desirable, of course, to know the approximate limits of safety and economy, in order that these elements may notbe exceeded.

*Chas. F. Scott in "The Electrical Journal."

AN EXTRA KNOT AND A HALF.

The extra 1½ knots that the big Cunard liners are to make over the Kaiser Wilhelm II., Germany's fastest ship, require the installation of 68 additional furnaces, six more boilers, over 52,000 additional square feet of heating surface and the development of an additional 30,000 horsepower. To provide for the increased weight the ship has to be lengthened 78 1-2 feet, broadened 16 feet and deepened 4 feet, and the displacement enlarged by 12,000 tons. If turbines were not employed at least three 25,000 horsepower engines, with shaft and screw propeller, would have been necessary, and many difficulties would have had to be solved to place these so as to balance weights and to avoid vibration. With rotary engines substituted for reciprocating engines there are economies of space and other advantages.

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EDITORIAL.

The Rates for Electric Power Service

The equitable basis of charging for electric current for power purposes has for years been a matter much discussed among electric light and power company managers. A rate per month or per year per horsepower or motors installed is often unsatisfactory, but has some advantages. In the first place the consumer is assured that as long as he confines his use of power to a given motor or set of motors, the cost of the power required for his purposes will not exceed a certain fixed amount. The power company, on the other hand, has the advantage often of furnishing much less power than the rated capacity of the customer's motors. When the cost of generating and delivering electric power is high, however, this basis is subject to wide and dangerous variations, and there is no element connected with the plan which tends to make the power consumer economical in the use of power. The load factor may be high in a plant furnishing power to its customers on this basis, but high load factor and high efficiency of operation from the financial standpoint are very different conditions in such a system.

In many cases the load on a motor may be exceedingly variable, and for short periods of time be much above its normal rating, and again very suddenly be reduced to but a small fraction of full load, this condition of operation lasting for a large part of the time. This character of power demand may be very difficult for the power company to meet, and yet the motors may continue to give excellent service for an indefinite period.

The kilowatt hour basis, measurement being made with integrating wattmeters, from the central station power company's standpoint, is undoubtedly the most satisfactory. It does not, however, take into consideration the daily load factor. The time of operation of the motors of each customer, however, should be taken into consideration in fixing the rate. This often leads to dissatisfaction and misunderstanding when two customers compare the relative cost of their power, and it is very difficult to explain the reason why the character of power demand during the day effects the cost of poewr in cases where the amount of power used per month is nearly the same.

A basis of charging for electric power service known as the "maximum reading system" or "maximum demand" rate has been somewhat extensively used. The recording instruments which must be used in such a system are of the moving paper, pen, ink and clock type and are at best only qualitative and not quantitative in their records. The personal equation of the individual to whom is intrusted the work of determining the actual maximum load by an examination of a month's charts will have very much to do with the actual result and the bill for the month. Short circuits and the starting of motors often cause records on the chart which cannot be segregated from the maximum load records.

An average of tests made on the polyphase alternatnating current motors in use in nineteen different manufacturing plants is as follows:

Average load on motors, 43 per cent. of their normal rating.

Maximum load on motors, 74 per cent. of their normal rating.

Average load on motors, 58.1 per cent. of the maximum load.

These averages, reduced to dollars and cents, give for a rate of $5.00 per month per horse power of the motors installed $11.63 per horse power per month for the actual power used. If the rate were $5.00 per horse power "maximum demand" for each horse power per month actually delivered, the price paid would be $9.62, as measured by an integrating wattmeter.

A modified integrating wattmeter which would in the ordinary way show the total kilowatt hours and in addition give the maximum load as well as the variation of the load during each twenty-four hours, would solve the problem of the proper rate of charging for electric power for motor service.

TELEGRAPHONE.

The telegraphone used in America differs materially from the device known as a telegraphone in Europe. The European telegraphone is of a phonographic character for the repetition of messages by the dispatcher. The telegraphone as it is known in America is essentially a telephone, the chief difference between it and an ordinary telephone being that it may be attached to a teleghapr line at any point and a verbal message be sent without disturbing the message that the telegrapher may be sending over the same wire.—From Mexican Investor.

San Francisco, Cal.—Owing to the fact that wide publicity has been given to charges that a million dollars of the relief fund contributed to San Francisco has been diverted or stolen, and owing to the further fact that those who have sent money to San Francisco are entited to a correct statement of conditions, the California Promotion Committee has sent out the following statement:

More than six million dollars contributed to San Francisco came in small sums, ranging from 10 cents up to thousands of dollars. These sums came by mail and express, in all forms, from postage stamps and currency to money orders and bank drafts. Of the entire amount sent, two sums only went astray—one a package of currency containing one thousand and eighty-five dollars and fifty cents from Searchlight, Nevada, sent through the Bank and Trust Company of Los Angeles, by express, and the other a package of two hundred dollars sent by mail from Baltimore.

The package of Searchlight money was traced only as far as the Oakland office of the express company, and as the company could show neither receipt for the amount nor a letter acknowledging it sreceipt, it made good the sum.

Investigation by the postal department developedthat the package of two hundred dollars from Baltimore was sent to the National Red Cross Society in Washington and never came to San Francisco.

In no other instance has there been report of missing funds, and in every instance acknowledgment has been made to the donor, excepting for sums sent in "chain letters."

The finance committee of the Citizens' Relief Committee of Fifty, consisting of twenty-one prominent business men of San Francisco, received all funds, and the books of this committee were examined by a representative of the National Red Cros sSociety, sent from Washington for that purpose, who declared them kept under a system that guaranteed their correctness.

The Massachusetts Association for the Relief of California sent a committee to San Francisco to investigate the methods of relief work. This committee came to San Francisco, made a thorough investigation, and on its return to Boston made a report, going into detail and covering every point in the work of relief in San Francisco. This report resulted in the immediate forwarding of the balance of the money in the hands of the Massachusetts organization. In its summary of the situation the committee says:

"Your committee has carefully investigated the books, accounts, methods and results of the committee having the matter in charge.

"It has met and consulted with very many leading men, professional and business, in this city whose opinions were valuable.

'We foun done unanimous opinion, whatever criticism might be made of methods, or even of results, and that was that the gentlemen on that committee and its executive committee were of the highest standing and character.

"We wish to express our opinion in the most emphatic way that those gentlemen are worthy of confidence. They are doing the best they can to meet an extremely difficult and distressing situation."

James D. Hague, of the New York Chamber of Commerce Committee for the Relief of San Francisco, spent several weeks in San Francisco investigating conditions. After his report was made to the New York body the funds, amounting to half a million dollars, held by the New York committee, were ordered turned over to the San Francisco Relief Corporation.

In the light of these investigations, and after a thorough and complete investigation of its own, the California Promotion Committee summarizes the situation as follows::

Only two sums of money have been reported as missing, and these have been traced. Neither ever reached the hands o fany one connected with the relief work in San Francisco.

The system of bookkeeping of the Relief Corporation has been pronounced correct and adequate by experts sent by Boston, New York and Washington.

TELEPHONES IN GREECE.

According to Mr. Horton, the United States consul at Athens, ancient Greece needs an up-to-date American telephone system. The inhabitants of that country are dissatisfied with the slipshod policy of the government which controls the telephone service. Consul Horton reports:

"The appliances in use are inadequate and the service unsatisfactory. For this reason the telephones are put poorly patronized, and I am informed on good authority that they are an unprofitable investment to the government which controls them. It is probable that the government would grant a concession to some reliable private company that would install up-to-date efficient telephones. I am confident that this bright, progressive people is ready for such a telphone service, and would support it with their patronage. The value of the present plant is about $125,000. The French Adder system is in use, with German keyboards. There are at present only about 600 telephones in operation at Athens, Piraeus, Phaleron, Kephissia, Decelia, and one long-distance wire connecting Athens with Patras.

"The present charges are 100 drachmas (drachma equals 19.3 cents) a year for a local telephone, 250 drachmas where connection is made between cities, and drachma for five minutes' talk between Patras and Athens. Salaries paid to operators range from 120 to 400 drachmas per month. Here possibly may be a profitable opening for American capital. as there seems to be a very general desire on the part of the people, which I have heard frequently expressed, that 'the Americans would come and take hold of the telephones.' For the granting of this and all similar concessions a vote of parliament is needed, some times easily obtained, and in other cases only after many and elusive promises and long and exasperating delays."

SEPARATION OF GASES.

Not much has been heard of late of the Mazza apparatus for the centrifugal separation of gases. More attention seems to be given it in the land of its birth, and Professor Nasini. of Padua, has had a series of physico-mathematical articles in "Il Gaz" upon it and centrifugal separators in general. He comes to the conclusion that solutions are more separable than gases on account of their smaller mobility; that among appliances tried for centrifugally separating gases the Mazza separator presents the best type, but that with all types the results actually obtained go beyond those indicated by the theory. With some modifications the Mazza separator may, in the future, yield actual practical results, particularly with higher velocities and shorter radii.

The United States Civil Service Commission announces an examination on December 12-13, 1906, to secure eligibles from which to make certification to fill several existing vacancies in the positions of hydrographic surveyor, at a salary of from $1,200 to $2,200, and recorder at $1,000 per annum, in the Navy Department, and vacancies as they may occur in any branch of the service requiring similar qualifications.

The specific positions to be filled are in connection with the work of surveying Almirante Bay and other surveying work on the south coast of Cuba, which work the Department states will last for probably two or three years.

THE VALLEJO, BENICIA & NAPA VALLEY RAILWAY.

George T. Hedrick.

The Vallejo, Benicia & Napa Valley Railway is the pioneer single-phase road of the West, having been in successful operation between Napa and Vallejo since July 4, 1905. The town of Napa, where the power house and car barns are located, is forty-eight miles from San Francisco, and is beautifully situated in one of the finest and most fertile valleys in California. The railway runs through this valley, tapping the agricultural and industrial towns along the line, the southern terminus being the town of Vallejo, where steamer connections are made with San Francisco, and where is located the Mare Island Navy Yard. The northern survey has reached St. Helena, eighteen miles north of Napa. This portion of the road will be rapidly constructed as fast as material can be procured. Along the northern end there are numerous summer resorts and mineral springs, and the vineyards are not excelled in all California.

The power for this road is furnished by the Bay Counties Power Company over the longest transmission line in the world, and is changed from 60 to 25 cycle current by two motor-generator sets, each unit consisting of a 585 horsepower, three-phase, 2,200-volt, 60-cycle induction motor direct-connected to a 400-kilowatt 2-phase, 25-cycle, 6,600-volt generator of the revolving field type.

The cars are all equipped wtih multiple-unit control. There are three quadruple equipments with 100 horsepower motors, and two quadruple equipments with 75 horsepower motors. At first the road was operated with a trolley voltage of 750, one phase only of each unit being used. There were five 200-kilowatt transformers, distributed along the line at intervals of about three miles, for supplying current to the trolley system which was at that time of standard direct-current construction. This was changed to single-phase catenary construction and the trolley voltage raised to 3,300 without interrupting the schedule of the road in any way. The bracket arms were changed and messenger cables strung with the working voltage on the wire and also a section breaker put in midway on the line, so as to have the line in two sections.

In order to change the system from 750 to 3,300 volts, it was necessary to cut out the five 200-kilowatt transformers on the line and put in two 500-kilowatt auto-transformers. For the car equipment it was necessary to take off the main fuse boxes and take out the main trolley cables, and replace with suitable fuse boxes and special insulated trolley cables. To simplify the work as much as possible for the night of changing over, as the time was limited from 12 midnight to 5:30 a. m., the two 500-kilowatt transformers were placed in their permanent position without oil, as the oil to be used was in the transformers that were in service. On the cars the 750-volt main fuse boxes were taken off and the main trolley cables taken out and the 3,300-volt main fuse boxes put on, and special insulated main trolley cables put in permanently, but not connected to the trolley bases. The 750-volt fuse boxes and trolley cables were then put up temporarily, so that when the time came to make the change all that was necessary to do was to take the fuses out of the 750-volt lines and put the fuses in the 3,300 trolley line and connect the trolley bases.

On the night that the change over was made, after the day's service was completed, a car was sent out of Napa over the line with three linemen with instructions to cut out the 200-kilowatt transformers as they went along, to cut out the jumper that was on the section breaker, and take enough oil out of the 200-kilowatt transformers for the 500-kilowatt transformer at Vallejo. They were then to telephone to the power station when they were ready to have the power shut off. After receiving word that the power was off they were to connect up the 500-kilowatt transformer to the line change the car fuses and connect the trolley cables to the bases. Then they were to telephone to the power station when ready to have the power turned on. In the meantime the men at the power station put oil in the 500-kilowatt transformer located in the power station, and made all necessary changes to the switch board and cars in the barn. When word was received from the Vallejo end that they were all ready the power was turned on, and everything was ready for service in time to operate the regular schedule with 3,300-volt power.

ABANDONING THE OLDER TYPES OF MOTORS.

In discussing the advisibility of replacing railway motors of the old type by motors of modern design, the Street Railway Journal notes that if more close investigations of the electrical efficiency and cost of repairs of the older types were made, probably fewer of them would be kept in service. The question of abandonment of the older types of railway motors was brought up at the February meeting of the Street Railway Association of New York, and it was suggested that actual data regarding the cost of maintenance of different types of street railway motors be kept by operating companies with a view to finding out the advisability of discarding the older machines. Figures submitted at that time showed that the cost of maintaining some of the older types on one road was more than $3 per 1000 miles, while for some of the newer types which had been in service about four years the cost was $1.22 and $0.57, respectively, per 1000 miles. For some new motors which had not begun to deteriorate the cost for a period of six months was only 3 cents per 1000 miles. When a car makes in the neighborhood of 50,000 miles per year, the saving with such a difference in the cost of maintenance as that given would pay interest on the investment.

RECOVERING METALS MELTED IN THE SAN FRANCISCO FIRE.

After the great San Francisco fire, hundreds of tons of lead, zinc and other metals owned by the Selby Smelting Company were found melted into a solid block at the base of the shot tower that was for many years one of the landmarks of the old city.

The problem of recovering the metals, which were worth many hundreds of thousands of dollars, was a difficult one. The great mass could not be raised or broken up into fragments of a practicable size by any ordinary means. A method has, however, been found by which it is hoped to recover the valuable metals.

After removing several tons of brick and debris, channels have been cut through the great block of metal by an electric arc process. The bed of metal is from three to four feet thick, and covers the entire area of the ruins of the tower. The heat and light produced by the process are intense, though only ten volts are used for each implement. The men who are engaged in cutting the channels have their heads and faces covered with canvas to protect them from the blinding light. Large blocks have been cut away from the great pile, and it is expected that the whoel work will take up the winter. About two hundred tons of lead, zinc and tin still remain to be recovered. The work, which is being done by the Dwyer-Frickey Electrical Company, is of so unusual a character that it is constantly watched by a crowd of interested people. The metal is recovered in blocks weighing nearly a ton each.—Scientific American.

ELECTRICITY IN THE MANUFACTURE OF STEEL.

Considerable progress has been made in Europe in producing steel by the electric method. The Electrical Review (New York) notes that in Italy Commandant Stassans, who is one of the leading champions of the process, has been carrying on a number of researches in order to find the best and most economical methods. He claims to have been very successful with his recent processes, and recommends especially the use of the arc by reverberation. A new type of furnace built on this plan has altely been adopted by the Italian government, and is under the control of the War Department. In other countries there is also considerable progress. The Froges-Heroult process may now be sa'd to have passed beyond the experimental stage. Besides the large plant located at La Prag, using hydraulic power to give an output of 4000 tons of steel, there are two other plants which have been lately erected. One of these is at Kortfors, Sweden, and the second is located in Germany, at Remscheid. Another large plant, which will soon be in operation, has been installed at Saut-Du-Tarn recently.

A new method whic hit is proposed to use at the German factory consists in first heating Siemens-Martin steel and then introducing it into the electric furnace, the latter carrying out the final processing of the steel, thus turning out a high grade product. In this way it is expected to replace the ordinary grades of steel by a superior quality for use in general work, where heretofore the common grades of steel have been employed. It is found that the steel which is turned out by the Froges-Heroult process is superior to the ordinary steel, by reason of the fact that for an identical chemical composition, or, again, for an equal breaking strain, the new steel shows a greater elongation and a higher resistance to shock than the usual carbon steels, even including curcible steels. This is considered to be due to the neutral atmosphere which is obtained in the electric furnace and the absence of gases. Another point to be especially noted in regard to the steel made by the electric process is that it shows much less deformation after tempering than other steels.

In this connection may be added some information, which has been given by O. Engelhardt, concerning the electric furnace plant erected some time ago at Gysinge, Sweden. This plant is operated on the Kjellin process, and is now turning out a good quality of steel. The furnace uses current to the extent of 170 kilowatts or more. Some trouble was found at first with the external protecting layer of the furnace. A silica composition had been used for this covering, but this was soon destroyed by the heat. It was replaced by a better covering which has a basic character and which is applied in a 12-inch layer. It consists of a mixture of ten parts of magnesia and forty parts of Holland clay, with enough water to give a good stiffness. Some three tons of this mixture were used to coat the outside of the furnaces. As to the amount of metal which is now being produced at the Gysinge plant, it is stated that 285 tons of steel were turned out within twelve weeks, using an average of forty-eight charges of the furnace in eight days. The amount of power needed there is 770 kilowatt-hours per ton of steel. Thi samount may be reduced by placing in the furnace 0.72 tons of melted iron to 1.43 tons of cold iron, making the consumption only 650 kilowatt-hours per ton. The new furnaces, which are now building, are expected to lower the amount of current needed to produce the steel. This will not exceed 590 kilowatt-hours by the former method, or 490 by the latter. In the Gysinge plant the current used is 3000-volt, fifteen-cycle monophase current, supplied by a hydraulic plant in the region. The production of steel can be carried out very economically, in view of the fact that the power can be supplied for 85 cents per kilowatt-nour.

THERMAL EFFICIENCIES.

In gas-making operations on a large scale the important thing is the recovery of by-products. The ammonia recovered in the manufacture of Mond gas is a great argument in favor of that form of gas, but large producers are required to secure the full advantage of this process.

With a gas producer the ratio of the heating value of the gas to that of the fuel from which the gas is made is called the thermal efficiency of the producer; of course the fuel burnt under the boiler for steam-raising purposes must be added to the coal used in the gas generator. When gas is used for driving a gas engine it is cooled after it is made, and obviously the thermal efficiency of the producer is the ratio of the heat in the cold gas to the heat of the fuel from which it is made. There are many forms of calorimeter made for the purpose of finding the heat value of the cold gas. It may be interesting to record a few thermal efficiencies. The manufacture of coal-gas with bituminous and cannel coal gives 22 per cent. Water gas (using coke) gives an efficiency of 71 per cent. Dowson gas is obtained from anthracite with an efficiency of 73 per cent. Mond gas seems to vary, for the efficiency is given as from 84 to 67 per cent. With blast-furnace gas the efficiency is roughly 50 per cent.

The thermal efficiency of the gas engine must also be considered. The owner of combined plants naturally wishes to know how many cubic feet of gas is used for every brake-horsepower per hour. The ratio of the number of cubic feet of coal-gas, Dowson gas and Mond gas, consumed per indicated horsepower per hour, are in the proportions of 374, 1,636 and 1,690 worked out on a theoretical basis, and assuming that there are no losses by radiation, etc. The thermal efficiency of the engine is the best equivalent of the work done on the piston as shown by the indicator diagram, divided by the total calorific value of the fuel used. Indicator diagrams on internal combustion engines are often difficult to take with any great accuracy, especially with the high speeds now used for smaller gas engines. So that we usually seek the over all efficiency of the engine, which is obtained by computing the number of thermal units required per hour per brake-horsepower. Incidentally, it may be mentioned that there is a special committee of the Institution of Civil Engineers considering the problem of tests for gas engines.

The consumption of gas in an engine varies very much with the load, and for comparative purposes the load must be stated.—From an article by C. Alfred Smith in the Engineering Times, London.

MAGNET COILS FOR ARC LAMPS.

Professor Elihu Thomson has patented a process for insulating coils which must withstand excessive moisture and high temperature. Each coil is composed of a single helix of ribbon copper, wound edgewise with the turns close together, so that it forms a tube of thickness of whose wall is the width of the ribbon conductor. After the coil is wound, and while there is some still space between the convolutions, it is covered by immersion with an insulating and cementing compound of kaolin and silicate of soda. The proportions of these two ingredients is such that the mixture is a viscous liquid, like a water varnish, which will soak into all crevices and form a thin layer between the metal coils. The entire coil is then closed together to form a rigid structure and is then subjected to a low red heat until the insulating compound is vitrified into an insoluble moisture-proof cement, which binds the coils together without permitting contact between its turns. This insulation is a double silicate of aluminum and sodium, and is refractory, being incapable of complete fusion except at a temperature which would melt the copper.

INDUSTRIAL

WESTINGHOUSE GETS ORDERS FOR MAMMOTH ELECTRICAL PUMPING STATIONS TO SUPPLY MEXICO CITY WITH WATER.

FIVE STATIONS TO BE INSTALLED.

The largest electric motors ever built for use in the Republic of Mexico are now being constructed at the works of the Westinghouse Electric & Mfg. Co., at Pittsburg, Pa., for use in connection with Morris centrifugal pumps to pump water from Xochimilco to Mexico City.

It is a gigantic proposition and will give Mexico one of the most modern water systems in use in any city today. This is but one of the many recent improvements indicating that Mexico is easily holding its own with other cities of its size.

The contract for these pumping stations is being handled through the Mexican Light & Power Co., of this city, who will supply the electrical power from their Mecaxa power plant. The five stations will be provided with electric motors direct coupled to their respective pumps, and have a total normal capacity of 3,060 horsepower, capable of a maximum of 5,222 horsepower providing for overload capacity.

Only the most modern and substantial apparatus will be provided throughout the entire installation, and every precaution has been taken to prevent any possibility of interference in service due to any cause whatever, a spare electrical unit with its pump being provided in each pumping station. The water will be pumped to reservoirs near to and above the city level.

In the first pumping station, "Condesa," will be placed three large Westinghouse synchronous motors of 1,200 horsepower, each making 720 revolutions per minute, pumping 850 litres of water per second. Two motor generator sets will supply the direct current for exciting the fields of the three motors, and all necessary switch board and lightning arrester equipment is also being furnished. To reduce the voltage from the Mexican Light & Power circuits at 18,000 volts to that required by the motors, 3,000 volts, the Westinghouse people aer supplying nine 400-kilowatt oil insulated transformers, three to each motor, capable of 25 per cent overload.

Station No. 2, "La Noria," will have two 60-horsepower motors, pumping 300 litres of water per second.

Station No. 3, "Nativitas," will have two 160-horsepower motors, pumping 600 litres of water per second.

Station No. 4, "Santa Cruz," will have two 120-horsepower motors, pumping 700 litres of water per second.

Station No. 5, "San Luis," will have two 356-horsepower motors, pumping 800 litres of water per second.

With all of the above will be supplied transformers, switch board, lightning protection, etc., etc. The motors in every case will be 3,000 volts. The pumps as made by the Morris Machine Works, of New York, will be of the single impeller centrifugal type.

The layout of the stations is most complete, the pumps with their motors being set in special masonry tanks below the water level, so that the pumps are always primed. The stations are roomy and provide ample space for the high voltage wires and transformers.

A traveling crane traverses eca hstation, overhead, above all the apparatus to assist in assembling the handling the heavy machinery.

HEAVY NATIONAL BRAKE & ELECTRIC COMPANY ORDERS.

Among recetn orders for air brake equipments, the National Brake and Electric Company, Milwaukee, Wis., reports the following, many of which are repeat orders:

Chicago Union Traction Company, Chicago, Ill., 120 equipments.

United Railroads of San Francisco, Cal., 110 equipments.

Seattle Electric Company, 38 equipments.

Norfolk & Portsmouth Traction Company, Norfolk, Va., 33 equipments and 8 trailers.

Chattanooga Railway Company, Chattanooga, Tenn., 27 equipments.

Northern Ohio Traction Company, Akron, O., 20 equipments.

Washington Water Power Company, Spokane, Wash., 16 equipments and 5 trailers.

Rhode Island Company, Providence, R. I., 14 equipments.

Public Service Corporation, Camden, N. J., 13 equipments.

Oakland Traction Cons. Company, Oakland, Cal., 10 equipments.

Georgia Railway & Electric Company, Atlanta, Ga., 10 equipments.

St. Louis Car Company, for Tampa & Sulphur Springs Railway, Tampa, Fla., 8 equipments.

Illinois Steel Company, South Chicago, Ill., 8 equipments.

Union Street Railway Company, New Bedford, Mass., 6 equipments.

Central Pennsylvania Traction Company, Harrisburg, Pa., 6 equipments.

R. W. Blackwell & Co., Ltd. (foreign), 6 equipments.

Everett Railway, Light & Power Company, Everett, Wash., 6 equipments.

Augusta-Aiken Railway & Electric Company, Augusta, Ga., 4 equipments.

Knoxville Railway & Light Company, Knoxville, Tenn., 3 equipments.

Spokane Traction Company, Spokane, Wash., 3 equipments.

Lookout Mountain Railway Company, Lookout Mountain, Tenn., 2 equipments.

McGuire-Cummings Company, Chicago (car builders), 2 equipments.

Butte Electric Railway Company, Butte, Mont., 2 equipments.

Illinois Traction System, Danville, Ill., 1 equipment.

Johnstown Passenger Railway Company, Johnstown, Pa., 1 equipment.

International Railway Company, Buffalo, N. Y., 1 equipment.

Duluth Street Railway Company, Duluth, Minn., 1 equipment.

Indiana, Columbus & Eastern Traction Company, Newark, Ohio., 1 equipment.

In addition, the company has received orders for over 500 of the new type N oil-pneumatic governors and 400 emergency valves since the close of the recent Columbus convention, which is gratifying evidence that its new apparatus is meeting with the hearty approval of street railway officials.

NEW ELECTRICAL EQUIPMENT FOR THE FAMOUS WASHOE SMELTER OF THE ANACONDA COPPER COMPANY.

Four induction motors, the largest installed west of the Mississippi River, have been purchased for the equipment of the famous 10,000-ton concentrator of the Washoe smelter, a new portion of the $9,000,000 reduction plant of the Anaconda Copper Mining Company at Anaconda, Mont. This plant is to operate with power supplied by the two stations of the Helena Power Transmission Company on the Missouri River near Helena, nearly 100 miles from Anaconda. In addition to power being furnished for the smelter and street railway of Anaconda, the improvements now in progress will, when completed, make it possible for the mines of Butte to utilize the Missouri River power.

The output of copper from the Washoe smelter, which has been equipped throughout with electrica ldrive, is from 15,000,000 to 17,000,000 pounds per month. Formerly all the power required was supplied by steam engines, and a certain amount of steam power will probably always be used ,as some of the steam boilers utilize the heat contained in the waste gases from the furnace. However, this power, obtained from a byproduct ,is not nearly sufficient to operate the whole plant, and all additional power is in the future to be supplied by electricity.

A second huge dam is being built across the river, near Helena, by the Missouri River Power Company, by which the waters will be backed up to form a lake near the capital city. The transmission of power at a pressure of 70,000 volts over a double line to Anaconda, nearly a hundred miles distant, involves a pole line and accessory equipment which will be one of the electrical wonders of the West.

A sub-station at the smelter contains the step-down transformers for lowering the pressure to 2200 volts for distribution to the various parts of the plant. The Anaconda company has also recently purchased a water power plant located at Flint Creek, about 31 miles from the smelter, and capable of supplying about 1500 K. W. The power from this plant will be used principally for the operation of blowers and air compressors in the smelter powerhouse.

The concentrating plant is the first unit to be driven by electric power exclusively, the four large induction motors being used for this purpose. The concentration building is 600 feet long, with the steam plant heretofore used for driving it located in the center. The jigs, tables, etc., aer driven from a main line shaft shaft 500 feet long, to which the engines have been connected by rope drive and friction clutch pulleys. It is intended to leave this steam plant intact, to be used as a reserve in case the electric power fails, and disconnect the shaft at each side where it enters the engine room, thus dividing th shaft into three parts, a live section on each side of the engine room. Two induction motors will be installed in each half of the mill and connected to the main shaft by rope drive and friction clutch pulleys. Each motor2 has a 1200 horsepower output at 360 R. P. M. synchronous speed, and will furnish power sufficient to operate easily two mill sections; connection is made to the main shaft by eighteen 2-inch ropes, and the pulley dimesions are such that the main shaft will be driven at 250 R. P. M.

Squirrel-cage motors were chosen for this insallation because the conditions under which they have to start, while unusual for motors of this size, are favorable and also because of the higher power factor as compared with the wound motor type. The motors, being connected to friction clutches, start up light, and as the mill runs continuously it is not expected that the motors will be started at all frequently. The power system of the Missouri River Power Company is so large that the occasional starting of one of these motors will not cause undue disturbance, while the higher power factor under ordinary running conditions is a decided advantage. Tests show that those motors exceed the guaranteed power factor of 92 per cent, and that the starting current taken from the line will not exceed full load running current when starting the motor with its ropes and friction pulley connected.

Starting is effected by an oil-immersed controller connected to an auto transformer which lowers the applied voltage at starting. The controller has six steps, so that the motor can be brought up to speed gradually. Since the motors are arranged in pairs in the mill, one controller is provided for each pair of motors, and the necessary instruments, switches, etc., are mounted on two-panel marble switchboards placed near the motors; the controller is operated by means of hand wheel on the front of the board.

The main switch and also the transfer switch for connecting either motor to the controller are of the oil-immersed type and interlocked with the controller handle in such a manner that it is impossible to close the moin switch of either motor while the controller is at the "on" position.

For the equipment of the substation there are three synchronous motor-generator sets of 300 K. W. output each, and one small induction fotor generator set for starting and exciting the synchronous sets. The 300 K. W. sets are driven by 12-pole 2080 volt 60 cycle cynchronous motors and run at a speed of 600 R. P. M.. The D. C. generators for these sets are compound wound for 500 volts and are easily able to carry 50 per cent overload for two hours without heating more than 55 degrees C. and without sparking. At normal full load the temperature rise does not exceed 35 degrees C. in any part. The sets have three bearings, and the stator of the synchronous motor is arranged to slide sideways on the base to give access to the field and armature windings. These units will be used for operating direct current Crane motors throughout the plant and also for furnishing power to the Anaconda street railway. During parts of the day the load will be quite light, and it is intended to operate the synchronous motors with over excited fields, so as to compensate to some extent for the lagging current caused by the induction motors.

The fields of the synchronous motors are excited from a 120-volt, 25-kilowatt, direct current generator driven by an induction motor. The same motor is also couple to a small 550-volt direct current machine which supplies current for starting the sets. This machine has commutating poles, and a very large current can be taken from it for short intervals without sparking at the commutator or undue heating in any of the machines.

The complete outfit of apparatus was furnished by the Allis-Chalmers Company of Milwaukee, Wisconsin.

ELECTRICAL EXPORTS FOR AUGUST.

Electrical exports from the United States for the month of August amounted to a total value of $1,369,079, compared with $1,131,593 for August, 1905. Electrical appliances, including telegraph and telephone instruments, show an increase in the amount exported amounted to $201,045, while the export of goods classified as electrical machinery increased by the amount of $36,441. More in detail, the figures are as follows: Electrical appliances—August, 1905, $543,730; August, 1906, $744,775. Electrical machinery—August, 1905, $587,863; August, 1906, $624,304.

The principal importers from the United States during August, considering electrical machinery only, were the following named countries, the value of the purchases being given: British North America, $138,697; United Kingdom, $122,394; Japan, $93,486; Mexico, $88,593; British East Indies, $32,824; Argentina, $21,380; France, $20,850; Brazil, $16,367; British Australasia, $12,916; Germany, $8639; British South Africa, $5759; Central American States and British Honduras, $4598; Cuba, $3659; European countries not mentioned above, $44,638; South American countries not mentioned above, $5938.—Western Electrician.

A NEW HYDRO-ELECTRIC PLANT FOR THE SAN JOAQUIN LIGHT & POWER CO.

About 50 miles northeast of Fresno, on the north fork of the San Joaquin River, in the Sierra Nevada mountains, a new hydro-electric plant, owned by the San Joaquin Light & Power Company of Fresno, Cal., was put in operation in April of this year. The actual work for construction of this plant was begun in May, 1905, but has been somewhat delayed by the fact that all material, except lumber, had to be transported into the mountains on freight teams.

The conduit supplying water for the operation of this plant ha sa total length of 4.3 miles and comprises open canal, tunnels, flumes and pipe line. These structures are designed for a flow of 100 cubic feet per second ,and with the total head of 400 feet give a total capacity of 3600 horsepower. The canal is 5 feet wide on the bottom and 3 feet deep. It is lined throughout with concrete. The intake basin and the forebay are concrete structures, and the tunnels are also lined with concrete. The flumes are of steel plate 1-8 inch thick, semicircular in form, and 6 feet wide. The pipe line is 3000 feet long and 52 inches in diameter, the thickness of steel varying from 3-16 inch to ½ inch.

The water wheels are the tangential type, two in number, and develop 83 per cent efficiency under full load.

The electric generators, two in number, are of the standard Allis-Chalmers water-wheel type, 1000 K. W., 300 R. P. M., 550 volt, three-phase. Each machine is provided with a base and two bearings, the shaft at each bearing being extended to carry an overhung water-wheel. The exciters are direct connected, having armatures mounted on the generator shaft between the bearings. Each exciter is 62½ K. W. output and easily capable of furnishing exciting current for both alternators.

The revolving field type of alternator is used with the motor specially constructed for high peripheral speed, which in these machines reaches as high as 7500 feet per minute.

The plant whose equipment is described above is the second one constructed by the San Joaquin Light & Power Company. The original plant is to be reconstructed and enlarged, and there are plans for other new plants to be built later.

THE INVERTED GAS BURNER.

The inverted gas burner was hailed with delight by gas engineers as supplying a means of meeting a phase of electrical competition which had previously been difficult, and in many cases impossible, to meet, namely, the greater adaptability of the electric lamp, and the wider range of decorative effects which it made possible. But, even among those particularly interested i ngas illumination, there have been misgivings and doubts as to the ultimate success of this form of burner.

The inverted burner first came into public use in Europe, where conditions are somewhat different than in this country; and there is no doubt that these differences have been sufficient in many cases to counteract to a considerable extent the advantages which the burner possessed in its native field.

The conditions in America, however, which have interfered with the utility of the inverted burner are apparently reducible to two, namely, the supply of gas at a lower pressure and poor regualtion. These two conditions, it would seem, are sufficiently easy to adjust, if any material advantage is to be gained thereby. In other words, if a slightly higher pressure and better regulation is all that is needed to make the inverted burner the success which is claimed for it by its makers, and by many gas engineers, there would seem to be little excuse for not complying with these conditions in this country.

The inverted burner has already led to a series of types following still more closely the adaptability of the electric lamp. Burners have been produced to burn at an angle downwards, to burn horizontally, and even capable of being inverted at will, so as to burn either in the upward or downward position.—From the Illuminating Engineer.

GLASS AS A CONDUCTOR OF ELECTRICITY.

Glass is, of course, so low down in the scale of electrical conductivity, that it forms one of the most common insulators. Nevertheless, there is glass and glass, in an electrical sense, and Mr. Charles E. S. Phillips, as the recent meeting of the British Association reported a glass that will conduct electricity comparatively well. It is made by fusing together 32 parts of sodium silicate and 8 parts of calcined borax. Greater stability is obtained if 1.25 parts of flint glass be added. This glass is suitable for the cases of windows of electrostatic instruments and is capable of being cut into plates, but on account of its low fusion point is not otherwise very workable. It may be readily drawn into rods and takes a fine polish. The density of this glass is 2,490, and it is somewhat harder than the ordinary soda glass of commerce. With regard to other physical properties it shows no flourescence under cathode radiation, is very transparent to X-rays and opaque to ultra-violet light. Its electrical conductivity is about 500 times that of the most conducting glass so far made, although, of course, still high. The change of resistivity with heat (which is very marked) is being examined, Mr. Phillips says.

Nearly all of the space for the January electrical show of the Chicago Electrical Trades Exposition Company is sold, aggregating nearly 30,000 square feet. So great ha sbeen the demand that the Coliseum annex will be used for exhibitors. Among the leading firms signing for space within the last few days are the following:

Albert & J. M. Anderson Manufacturing Company, Chicago; Pierce Specialty Company, Chicago; Chicago Compound Battery Company, Chicago; Eureka Electric Company, Genoa, Ill.; Bidwell Electric Company, Chicago; Beck Framing Lamp Company, New York City; Felix Hamburger, New York City; Dean Electric Company, Elmyra, Ohio; American Sewer Pipe Company, Pittsburg, Pa.; American Clock Company, Chicago; Universal Manufacturing Company, Chicago; Shelby Electric Company, Shelby, Ohio, and the American Instrument Company, Philadelphia.

Managing Director Niesz sent a representative to New York last week to try and get a temporary installation of the Cahill telharmonic system in the show, but Dr. Cahill's representatives said that this would be a physical impossibility, as there s only one telharmonium completed, which is now the beginning of the permanent installation of the New York Electric Music Company, which has commenced its service of music to clubs, hotels, cafes and residences over the New York telephone wires. Manager Phil of the New York company, however, agreed to attempt a long distance test of the telharmonic system, by which an effort will be made to transmit music from the New York Central station to the Coliseum during the exposition. This will require the co-operation of the Chicago Telephone Company and the American Telephone and Telegraph Company, which control the long distance circuit. The longest test yet made of the Cahill system was from Holyoke, Mass., to New Haven, Conn., about 100 miles. Mr. Niesz's representative also made arrangements while East for the first installation west of New York of the Moore vacuum tube light—"electric daylight" as it is called.